



Updated Guidelines for Critically ill Pediatric Patients

by

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Standard Nutrition therapy

Standard therapy refers to provision of intravenous fluids, no EN or PN, and advancement to oral diet as tolerated.

Nutrition Support Therapy

It refers to the provision of Enteral nutrition (EN) by Enteral access device and/or Parenteral nutrition (PN).

Nutrition of Critically ill Pediatric Patients

- Neonates and children - reduced stores & much higher baseline requirements of lipids and proteins at the time of injury
- Critically ill children - more susceptible to the effects of catabolic stress
- Do not often receive even the recommended dietary intake of protein or energy for healthy children until after a full week in the intensive care unit.

Determination of Nutritional Requirements in Critically ill Pediatric Patients

Very important to calculate accurate requirements for critically ill pediatric patients

Components of Energy Requirements

- Basal metabolic rate (BMR) or resting energy expenditure (REE)
- Growth rate (normal growth, or catch-up growth)
- Physical activity
- In sick children, stress due to illness or healing process is an additional factor affecting energy requirements; but often leads to overestimation of energy requirements in critically ill children

Activity Factors

Condition	Factor
Paralyzed	1.0
Confined to Bed	1.1
Ambulatory	1.2-1.3

Stress Factors

Condition	Factor
Surgery	1.2-1.5
Infection	1.2-1.6
Trauma	1.1-1.8
Burn	1.5-2.5
Starvation	0.7
Growth Failure	1.5-2.0

Why is Accurate Energy Estimation Necessary?

- To **reduce mortality**
 - Negative energy balance is related to mortality
 - To prevent **overfeeding**, which may result in:
 - Hyperglycaemia - increased risk of secondary infection
 - Increased fat deposition & fatty liver
 - Increased ventilatory work following increased carbon dioxide production, which can prolong the need for mechanical ventilation

- To prevent **underfeeding**, which may result in:
 - Malnutrition
 - Impaired immunologic responses
 - Impaired growth

Causes of Overfeeding

Failure to recognise the hypometabolic phase of metabolic stress response (overestimating energy expenditure)

Reliance on standardised formulae/equations for energy expenditure, which may be inaccurate, e.g. in the case of obese patients

Inaccurate weight of patient being used to calculate energy requirements

Over-estimating the degree of metabolic stress in the era of modern anaesthesia and surgery

Causes of Underfeeding

Inability to predict the hypermetabolic stress response (underestimating energy expenditure)

Inaccurate estimation of energy expenditure

Delay in detecting deteriorating nutritional status

Failure to deliver prescribed nutrients

Metabolic Responses to Critical illness

Condition	Response
Burns	Extreme hypermetabolism in early stages; protein requirements can double
Sepsis	Upregulated fat oxidation; increased energy requirements
Congenital Heart Disease	Increased EE, fluid restricted, may absorb nutrients poorly
Cardiac Surgery	Risk of underfeeding because of fluid restriction, mosaic of hyper-, hypo- and normometabolic states post-surgery
Abdominal Surgery (Newborns)	Increase in REE at 4 hrs, followed by return to baseline after 12–24 hrs
Surgery in General	Hyperglycaemia response that is negatively correlated with age (12 hrs in neonates; 24–48 hrs in children)
Mechanical Ventilation	REE may be reduced due to inactivity, absence of growth or decreased insensible fluid loss

Metabolic Stress Response and Optimal Nutritional Intake

- The hypermetabolic response in critically ill children is less pronounced than in adults
- Sustained protein breakdown may result in significant loss of lean body mass during critical illness
- Accurate assessment and delivery of energy to match the patient's demand is an important goal
 - Unintended under or overfeeding is associated with poor outcomes
- Adequate protein and energy intake helps maintain protein balance and prevent lean body mass depletion in the PICU patient

Estimating Energy Requirements

- Several methods exist
- Most common are IC and Predictive Equations

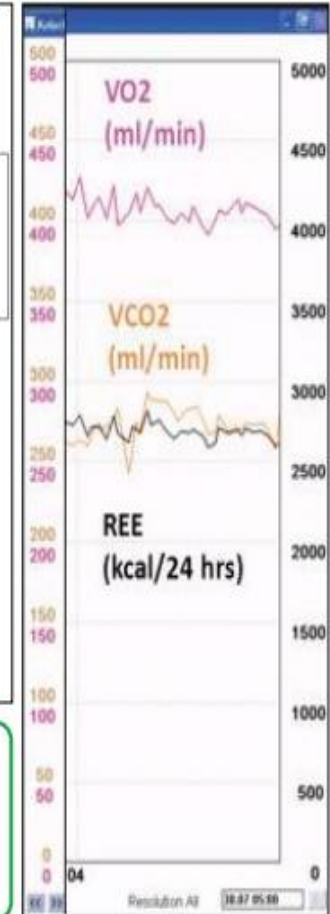
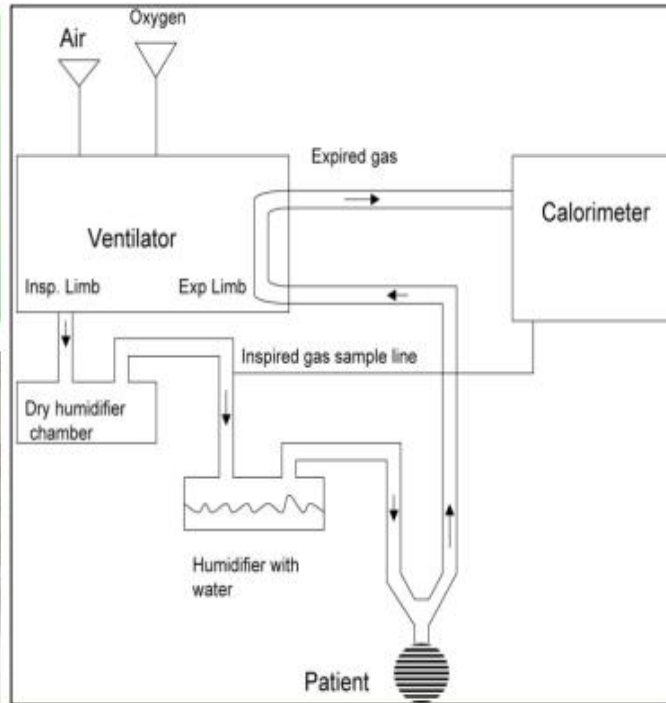
Indirect Calorimetry

- IC uses a metabolic cart to measure O_2 consumed and CO_2 exhaled, to determine resting energy expenditure (REE)
- Provides the respiratory quotient (RQ), which can help determine substrate use (fat, protein, mixed, carbohydrate or fat synthesis)
- Patients are measured under a hood that collects inhaled O_2 and exhaled CO_2
 - Ventilated/tracheostomised patients can be tested if there are no leaks and FI_{O_2} is not $>60\%$
- IC is performed when the child is quiet, awake and calm
- IC is the gold standard to measure REE, but is not always available in resource-limited settings

Using IC to Measure REE

Measures **Respiratory Exchange Ratio**

$RQ = VCO_2 / VO_2$
when patient is in a calm steady state



RESTING ENERGY EXPENDITURE (REE)

Weir equation

$$REE \text{ (kcal/day)} = [VO_2 (3.94) + VCO_2 (1.11)] \times 1440 \text{ min}$$

Interpreting Respiratory Quotient (RQ) Values

RQ	Clinical Interpretation
<0.85	Indicates under feeding
0.85 – 1.0	Indicates adequate feeding
>1.0	Indicates over feeding

Recommendations on IC

- IC is the **gold standard** for estimating resting energy requirements
- In resource-limited settings, if it is not feasible to carry out IC in all patients, it should be targeted at patients who are at **particular risk of metabolic instability**
- If IC is not available, resting energy requirements may be calculated using **predictive equations**

PICU Patients who are at Risk of Metabolic Instability

- **Underweight** (BMI <5th percentile for age), at risk of overweight (BMI >85th percentile) or **overweight** (BMI >95th percentile)
- **>10% weight gain or loss** during ICU stay
- **Failure to meet prescribed caloric goals** consistently
- **Failure to wean**, or need to escalate respiratory support
- **Need muscle relaxants** for >7 days
- **Neurologic trauma** with evidence of dysautonomia

- **Oncologic** diagnoses (including stem cell or bone marrow transplant)
- **Thermal** injury
- Need **mechanical ventilator support for >7 days**
- Children suspected to be severely **hypermetabolic or hypometabolic**

Predictive Equations

- Schofield Equation (kcal/d)
- White Equation (kJ/d)
- FAO/WHO/UNU Equation (kcal/d)
- Harris Benedict Equation (kcal/d)

Schofield Equation to Estimate BMR (kcal/day) of PICU Patient

Age	Gender	Equation	
		W	WH
<3 years	M	$59.48W - 30.33$	$0.167W + 1517.4H - 617.6$
	F	$58.29W - 31.05$	$16.252W + 1023.2H - 413.5$
3–10 years	M	$22.7W + 505$	$19.59W + 130.3H + 414.9$
	F	$20.3W + 486$	$16.97W + 161.8H + 371.2$
10–18 years	M	$17.7W + 659$	$16.25W + 137.2H + 515.5$
	F	$13.4W + 696$	$8.365W + 465H + 200$

In critically ill children, use of actual weight (whether child is underweight or overweight) is recommended.

M = male; F = female; H = height (m); W = weight (kg)

Example

- BMR for a male child, 2 years of age, having a weight of 12 kgs will be;
- $\text{BMR} = 59.48 W - 30.33$
 $= 59.48 \times 12 - 30.33$
 $= 713.76 - 30.33$
 $= 683.43 \text{ kcal/day (BMR)}$

White Equation to Estimate BMR (kJ/day) of PICU Patient

$$17 \times A[\text{mo}] + (48 \times W) + (292 \times \text{body temp } ^\circ\text{C}) - 9677$$

Example

- BMR for a female child, 14 months of age, having a weight of 10.5 kgs & body temperature of 38.3°C will be;
- $$\begin{aligned}\text{BMR} &= 17 \times A[\text{mo}] + (48 \times W) + (292 \times \text{body temp } ^\circ\text{C}) - 9677 \\ &= 17 \times 14 + 48 \times 10.5 + 292 \times 38.3 - 9677 \\ &= 238 + 504 + 11183.6 - 9677 \\ &= 11925.6 - 9677 \\ &= 2248.6 \text{ kJ/day (1 kcal = 4.18 kJ)} \\ &= 537.94 \text{ kcal/day (BMR)}\end{aligned}$$

FAO/WHO/UNU Equations to Estimate REE (kcal/day)

Name	Gender	Equation
<3 years	M	$60.9W - 54$
	F	$61W - 51$
3–10 years	M	$22.7W + 495$
	F	$22.5W + 499$
10–18 years	M	$17.5W + 651$
	F	$12.2W + 746$

M = male; F = female; W = weight (kg)

Example

- BMR for a 9 years old male child, having a weight of 30 kgs will be;
- $BMR = 22.7W + 495$
 $= 22.7 \times 30 + 495$
 $= 681 + 495$
 $= 1176 \text{ kcal/day}$

Harris Benedict Equation to Estimate BMR (kcal/day) of PICU Patient

- For males, $66.4730 + (5.0033 \times H) + (13.7516 \times W) - (6.7550 \times A)$
- For females, $655.0955 + (1.8496 \times H) + (9.5634 \times W) - (4.6756 \times A)$

(M = male; F= female; A = age; H = height (m); W = weight (kg))

- † When using the Harris-Benedict equation in the clinical setting, the factors can be rounded to one decimal point.

Example

- BMR for an 8 years old female child, having a weight of 25.5 kgs & height of 126.4 cms or 1.264 m will be;
- $$\text{BMR} = 655.0955 + (1.8496 \times H) + (9.5634 \times W) - (4.6756 \times A)$$
$$= 655.0955 + 1.8496 \times 1.264 + 9.5634 \times 25.5 - 4.6756 \times 8$$
$$= 655.0955 + 2.3378 + 243.8667 - 37.4048$$
$$= 901.3 - 37.4047$$
$$= 863.89 \text{ kcal/day}$$

Predictive Equations: Which to Use?

- FAO/WHO/UNU
 - Schofield
- } Evaluated/good accuracy in healthy children
- Harris-Benedict
 - White
- Not validated in children
- Not validated in infants <2 months
- It is recommended to **use Schofield equation, without routine inclusion of stress factors**
 - Regular reassessment is necessary to ensure that appropriate nutrition is provided
 - Use the same equation for serial assessments

Research has shown that stress factors may overestimate EE in critically ill children

children
EE is clinically ill
OASLE21111976

Nutritional Prescription in the PICU (Enteral Nutrition)

Proteins

- Proteins are in a constant state of flux and exist either as 'complete' proteins, or in the free amino acid pool
 - Protein breakdown provides free amino acids, which are channelled toward tissue repair, wound healing and the inflammatory response
 - In critically ill children, this may lead to substantial losses of lean body mass

Metabolism

- Chemical reactions enable the body to function as an integrated system
- Two basic types of metabolism
- Anabolism: Substances are assembled
- Catabolism: Substances are broken down
- Protein metabolism is measured by nitrogen balance

Sources of Protein

- Key sources of protein for nutritional therapy are:
 - Milk proteins: whey, casein
 - Soy proteins
- All proteins are not digested at the same rate:
 - Whey empties from the stomach more rapidly than casein because it remains liquid and does not form a curd in the acidic environment of the stomach
 - In the small intestine, whey is digested and absorbed faster than casein
 - Hydrolysed proteins (peptides) are easier to digest and more readily absorbed



Whey: Soluble protein



Facilitates gastric protein



Casein: Clot into stomach



Delays gastric emptying time

Influence of Stress on Protein Absorption & Metabolism

Altered absorption

- ↓ ability to absorb intact protein
- ↓ amino acid carriers in gut
 - 70% of protein absorbed as peptides

Increased protein catabolism

- ↑ protein requirements
- Loss of lean body mass
- Protein used by the body for energy and acute phase

Essential to provide high-quality protein

Protein Balance

- 'Protein balance' describes the status of protein metabolism within an individual
 - **Negative balance** is a marker for catabolism (degradation or breakdown)
 - **Positive balance** indicates anabolism (synthesis)
- Positive protein balance is a surrogate measure of lean body mass preservation
- Maintaining positive protein balance is an important goal of nutrition therapy in critically ill children

Protein Requirements for Critically ill Children

EN protein requirements are age-dependent in children

Age	A.S.P.E.N. recommendations
0–2 years	2–3 g/kg/day
2–13 years	1.5–2 g/kg/day
13–18 years	1.5 g/kg/day

The minimum recommended daily protein intake for critically ill children is 1.5 g/kg body weight/day

for critically ill children is 1.5 g/kg body weight/day

Managing Protein Requirements

- Protein needs can be determined by measuring urinary nitrogen excretion
- Protein retention can be increased by using a balanced glucose/fat solution
- Increasing protein intake cannot reverse protein breakdown, but it can improve nitrogen balance by enhancing protein synthesis

Carbohydrates

Monosaccharides

- Glucose
- Fructose
- Galactose



Disaccharides

- Glucose + Fructose = Sucrose
- Glucose + Glucose = Maltose
- Glucose + Galactose = Lactose



Oligosaccharides (3–10 monosaccharide units):

- Maltodextrin



Polysaccharides (10+ monosaccharide units linked to form long complex chains)

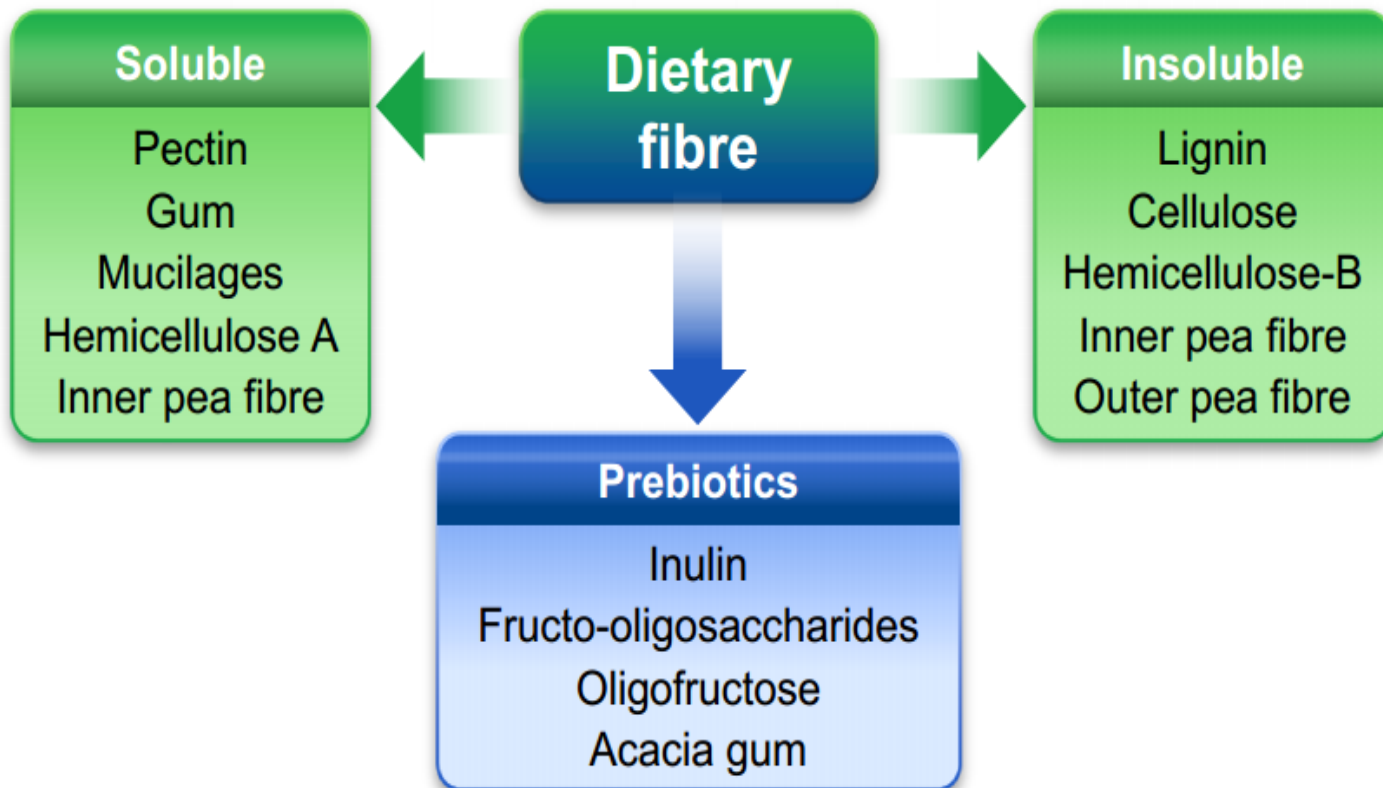
- Starch, fibre



Functions

- **Primary source of energy** for many organs
 - Primary source for CNS/brain and red blood cells
 - Brain requires constant supply of glucose to meet its energy needs
- In fasting conditions, the liver and kidneys convert **glycogen to glucose** (primarily from liver and skeletal muscle)
- During prolonged fasting:
 - Hepatic glycogen stores will be depleted within a few hours
 - Gluconeogenesis is stimulated to maintain normoglycaemia
- **Fiber**
 - Important for maintenance of normal bowel function

Types of Dietary Fiber



Carbohydrate Metabolism in Critically ill Children

- Glucose intolerance and insulin resistance can result from hormonal and metabolic challenges
 - Hyperglycaemia and hypoglycaemia are prevalent in the PICU
- In critically ill children, carbohydrate is utilised poorly, and fat is preferentially used for oxidation
- During the metabolic response, carbohydrate turnover is increased, with a significant increase in glucose oxidation and gluconeogenesis
- **Glucose production and availability is a priority of nutritional therapy**

Fat

- Fats (lipids) exist as fatty acids, triglycerides, sterols, phospholipids
- 95% of dietary fat is triglycerides
 - Glycerol backbone + 3 fatty acids

Fat Types and Sources

Short chain fatty acids (SCFA)

- 2–4 carbons in length
- Fermentation product of prebiotics, energy source for the gut wall

Medium chain triglycerides (MCT)

- 6–12 carbons in length
- Do not require bile salts or pancreatic lipase for digestion → more rapidly digested and absorbed than LCT
- Rapid source of energy

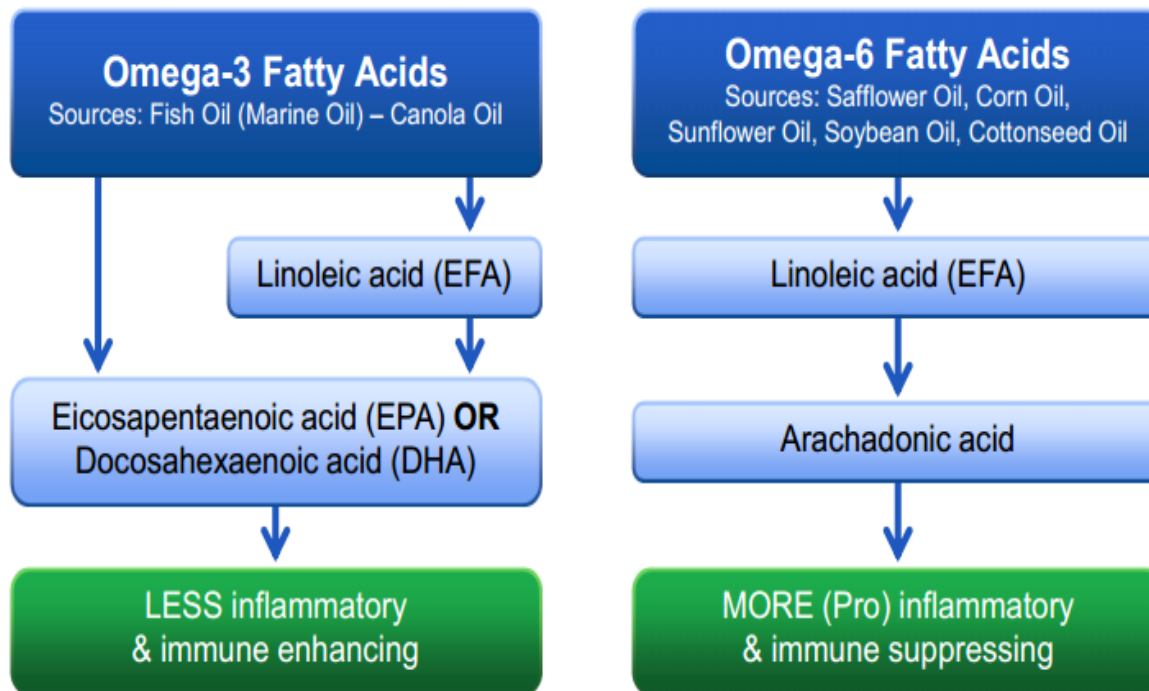
Long chain triglycerides (LCT)

- >14 carbons in length
- Major energy source in diet
- Essential fatty acids are LCT
- Ensure absorption of fat-soluble vitamins

Fish oil

- Supplies long-chain fatty acids with strong anti-inflammatory properties (EPA and DHA)
-

Omega-3 & Omega-6 Fatty Acids can affect Immune & Inflammatory Responses



Changing the amount of omega-6 to omega-3 can modulate the inflammation and the immune response of the body

Fat Metabolism in Critically ill Children

- **Fat metabolism is increased** by illness, surgery and trauma
- The use of fat is **reduced in early stages** of critical illness, leading to increased plasma triglycerides and decreased metabolism of intravenous fats (lipids)
- Fat breakdown (lipolysis) is enhanced to provide free fatty acids for energy and glycerol for gluconeogenesis
- **Essential fatty acid deficiency** can result from the increased demand for fat and the limited fat stores in a critically ill child
- Increasing glucose in feeds does not decrease glycerol clearance or reduce lipid recycling

Carbohydrate and Lipid Requirements for Critically ill Children

Reasonable first-line goals (depending on the age of the child):

Carbohydrate

Approximately 50–60%
of total energy intake

Lipid

30–40% of
total energy intake

Other Components

Considerations for Fluid Requirements

Increased fluid needs:

- Fever
- Hyperventilation
- GI losses
(high output diarrhoea, fistulae)

Conditions requiring fluid restrictions:

- Cardiac
(congestive heart failure)
- Respiratory (pulmonary oedema)
- End Stage Renal Disease
- Liver (ascites)

Daily fluid requirements (A.S.P.E.N. 2010)

Body weight	Daily fluid requirements
<10 kg	100 mL/kg
10–20 kg	1000 mL + 50 mL/kg for each kg >10 kg
>20 kg	1500 mL + 20 mL/kg for each kg >20 kg

Prokinetics

- Abnormal gastric motility is common in critically ill patients and prevents achievement of nutritional goals
- There is insufficient evidence to recommend the use of prokinetic medications or motility agents for EN intolerance or to facilitate Enteral access device placement in critically ill pediatric patients

Prebiotics and Probiotics

- **Probiotics** are viable microorganisms (bacteria or yeast) that are used as dietary supplements to alter the microflora of the host, with the potential for beneficial health effects
- **Prebiotics** are non digestible soluble dietary fibers (e.g., inulin, fructo-oligosaccharides), which selectively stimulate the growth/activity of beneficial bacteria in the gut to improve the health of the host
- **Synbiotic** formulations contain both pre- and probiotics
- Tolerability and safety have been shown, but there is still not enough evidence to recommend the routine use of prebiotics, probiotics, or synbiotics in critically ill children

Micronutrients

- Micronutrients are essential to the diet and are needed for the maintenance of normal health
- A balanced micronutrient solution should be included in the diet of all critically ill patients
- Daily requirements vary with age, gender, course and type of illness and recommended intakes vary by geography

EN Formulas

Considerations for Formula Selection

Patient's Disease State

- **Metabolic** response to stress? Is GI tract accessible?
- Is gut compromised? Does patient require a disease-specific
- Formula? Food allergy?

Nutritional Goals

- What are long-term requirements of the patient?
- Will EN be short- or long-term?

Current Nutritional Status

- In severe malnutrition, gut function is compromised due to the gut wall becoming oedematous

Age

- Consider nutritional requirements, nutritional status

Biochemistry/Laboratory measurements

- Very low albumin can be a predictor of oedema in the gut; pre-albumin can be used as an indicator of nutritional status; CRP can be a measure of inflammatory status

Types of EN Formula

Polymeric (intact protein/standard formula)

- Provide 1–2 kcal/mL, may or may not contain fibre
- Require that patients can absorb intact macronutrients

Semi-elemental (peptide-based/hydrolysed)

- Provide 1–1.5 kcal/mL
- Contain pre-digested macronutrients (such as small peptides and MCT), making it easier for a partially dysfunctional GI tract to absorb them

Elemental (amino acid-based)

- Provide 1–1.5 kcal/mL
- Contain 100% free amino acids with variable amount of MCT, making it easier for a severely impaired GI tract to absorb them

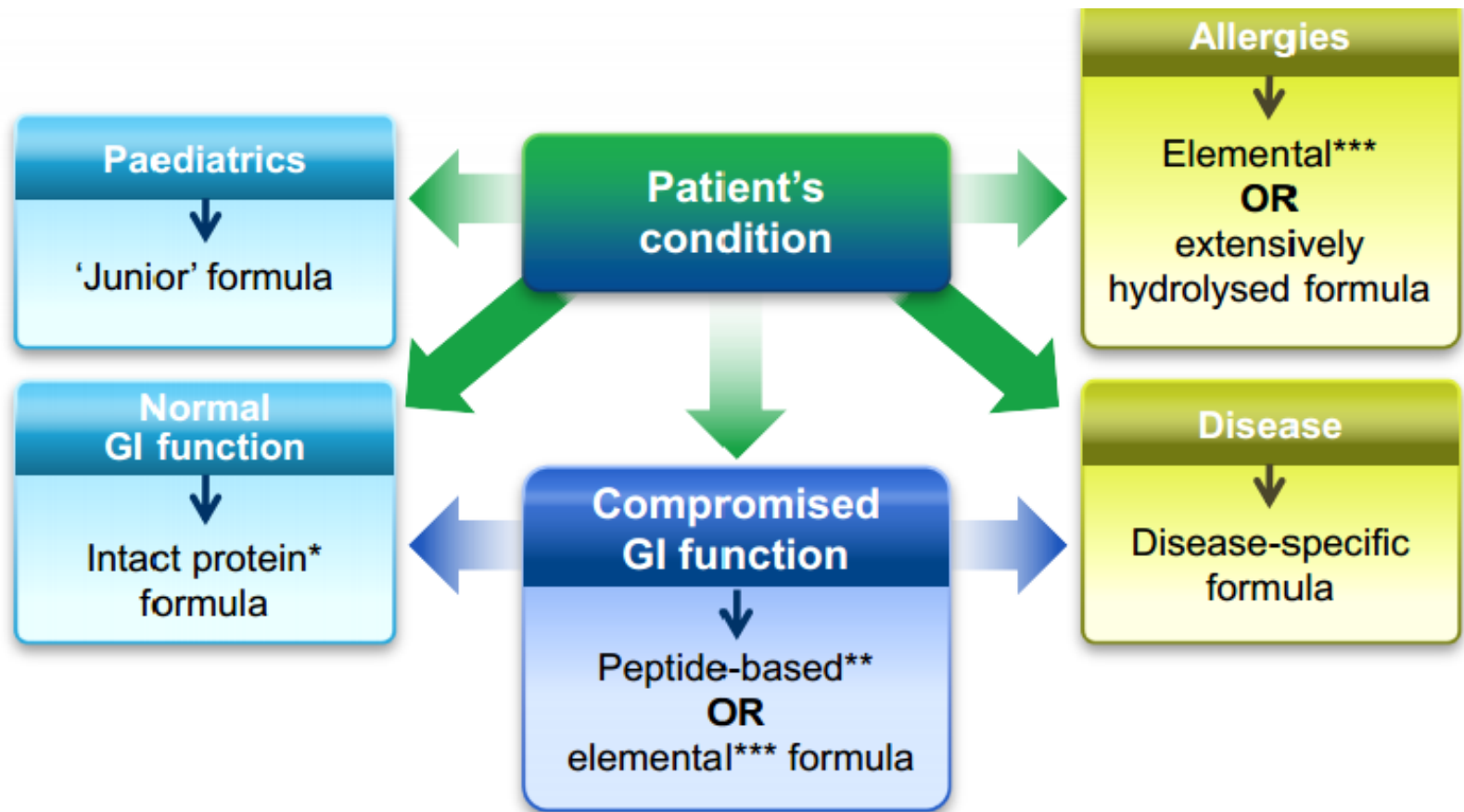
Modular

- Vary in energy content
- Contain single macronutrients (protein, glucose polymers, or lipids)

Disease-specific

- Vary in protein, carbohydrate, lipid and vitamin and mineral content
 - For patients with disease-specific conditions such as renal impairment, hepatic disease, diabetes, and pulmonary disease, etc.
-

When to Use which Formula?



* Polymeric or standard formula; ** Semi-elemental formula, ***Amino acid formula

Nutritional Prescription in the PICU (Parenteral Nutrition)

PN Macro/Micronutrient intake

- Parenteral nutrition involves the infusion of an intravenous nutrition formula into the bloodstream
 - Total Parenteral Nutrition (TPN) means that the infusion is providing the patient's complete nutritional requirements
 - Sometimes PN is needed to support inadequate EN intake
- PN comprises a mixture of amino acids, carbohydrates and fat, as well as electrolytes and micronutrients
- Fluid and energy requirements are an important consideration
- Energy delivery must be individually adjusted to energy expenditure

Protein Requirements for PN

	Older children	Infants
Start	1 g/kg/day	
Advance by	0.5 g/kg/day	1 g/kg/day
Maximum	1.5 g/kg/day	3.0–3.5 g/kg/day

Carbohydrate Requirements for PN

- Glucose is the **carbohydrate of choice** and should provide **40–60%** of total calorie intake
- Glucose (dextrose) component is in a water solution, usually expressed as % (weight per volume of total solution)
- If glucose intake exceeds energy needs, there is a risk of **hyperglycaemia**
 - Net lipogenesis occurs at glucose intakes of more than 18 g/kg/day in infants (12.5 mg/kg/min)
 - Calculate glucose infusion rates (5–7% concentration) to maintain normoglycaemia at around 5–7.5 mg/g/min
 - Higher ranges - hyperglycaemia and lipogenesis
 - Lower ranges - risk of hypoglycaemia

Carbohydrate Aims for PN

	Older children	Infants
Start	3–5 g/kg/day	2–3 g/kg/day
Advance by	2–3 g/kg/day	2–3 g/kg/day
Maximum	12 g/kg/day	12–16 g/kg/day

Lipid Requirements for PN

	Older children	Infants
Start	1 g/kg/day	
Advance by	0.5 g/kg/day	1 g/kg/day
Goal	2 g/kg/day	3 g/kg/day

**Use 20% lipid solutions in infants and children
(E.g. for 20% lipid, 1 g/kg provides 10 kcal/kg or 42 kJ/kg)**

(E.g. for 20% lipid, 1 g/kg provides 10 kcal/kg or 42 kJ/kg)

PN Formulas

- Use a standard commercially available PN formulation
 - Has the advantage of being sterile
 - Meets the needs of most individuals
 - Cheaper than custom-made
- Alternately, PN formulas can be custom-made to precisely meet the patient's individual requirements for macronutrients, micronutrients and electrolytes

Nutrition Support Clinical Guideline Recommendations for the Critically ill Pediatric Patients

Target Patient Population for Guidelines

- The target of these guidelines is intended to be the pediatric critically ill patient (**>1 mo and <18 years**) expected to require a length of stay (LOS) >2–3 days in a PICU admitting medical, surgical, and cardiac patients.
- These guidelines are directed toward generalized patient populations, but, like any other management strategy in the PICU, nutrition therapy should be tailored to the individual patient.

Target Audience

These guidelines are intended for use by all healthcare providers involved in nutrition therapy of the critically ill child — primarily, physicians, dietitians, pharmacists, and nurses.

Methods

- The GRADE process was used to develop the key questions and to plan data acquisition and conflation for these guidelines.
- Questions related to 8 major practice areas were developed, which were reviewed and approved by the ASPEN and SCCM boards.

Impact of Nutrition Status on Outcomes

- Based on observational studies, malnutrition (including obesity) is associated with adverse clinical outcomes, including longer periods of ventilation, higher risk of hospital-acquired infection, longer PICU and hospital stay, and increased mortality.
- It is recommended that patients in the PICU undergo detailed nutrition assessment within 48 hours of admission.

- Furthermore, as patients are at risk of nutrition deterioration during hospitalization, which can adversely affect clinical outcomes, the nutrition status of patients should be reevaluated at least weekly throughout hospitalization.
- On the basis of observational studies and expert consensus, it is recommended that weight and height/length be measured on admission to the PICU and that z scores for body mass index for age (weight for length <2 y) or weight for age (if accurate height is not available) be used to screen for patients at extremes of these values.

- In children <36 mo old, head circumference must be documented.
- Validated screening methods for the PICU population to identify patients at risk of malnutrition must be developed.
- Screening methods might allow limited resources to be directed to high-risk patients who are most likely to benefit from early nutrition assessment and interventions.

Energy Requirements

- On the basis of observational cohort studies, it is suggested that measured energy expenditure by IC be used to determine energy requirements.
- If IC measurement of resting energy expenditure is not feasible, the Schofield or Food Agriculture Organization/World Health Organization/United Nations University equations may be used without the addition of stress factors to estimate energy expenditure.

- Multiple cohort studies have demonstrated that most published predictive equations are inaccurate and lead to unintended overfeeding or underfeeding.
- The Harris Benedict equations and the RDAs, which are suggested by the dietary reference intakes, should not be used to determine energy requirements in critically ill children.

- On the basis of observational cohort studies, achieving delivery of at least two-thirds of the prescribed daily energy requirement by the end of the first week in the PICU is suggested.
- Cumulative energy deficits during the first week of critical illness may be associated with poor clinical and nutrition outcomes.
- On the basis of expert consensus, attentiveness to individualized energy requirements, timely initiation and attainment of energy targets, and energy balance to prevent unintended cumulative caloric deficit or excesses is recommended.

Protein Requirements

On the basis of evidence from RCTs and as supported by observational cohort studies, minimum protein intake of 1.5 g/kg/d is recommended. (Protein intake higher than this threshold has been shown to prevent cumulative negative protein balance in RCTs).

- In critically ill infants and young children, the optimal protein intake required to attain a positive protein balance may be much higher than this minimum threshold.
- Negative protein balance may result in loss of lean muscle mass, which has been associated with poor outcomes in critically ill patients. Based on a large observational study, higher protein intake may be associated with lower 60-d mortality in mechanically ventilated children.

- On the basis of results of randomized trials, provision of protein early in the course of critical illness to attain protein delivery goals and promote positive nitrogen balance is suggested.
- Delivery of a higher proportion of the protein goal has been associated with positive clinical outcomes in observational studies.
- The optimal protein dose associated with improved clinical outcomes is not known. The use of RDA values to guide protein prescription in critically ill children is not recommended.
- These values were developed for healthy children and often underestimate the protein needs during critical illness.

Enteral Nutrition & Critically ill Children

On the basis of observational studies, EN is recommended as the preferred mode of nutrient delivery to the critically ill child. Observational studies support the feasibility of EN, which can be safely delivered to critically ill children with medical and surgical diagnoses and to those receiving vasoactive medications.

TUBE FEEDING



- Common barriers to EN in the PICU include delayed initiation, interruptions due to perceived intolerance, and prolonged fasting around procedures.
- On the basis of observational studies, we suggest that interruptions to EN be minimized in an effort to achieve nutrient delivery goals by the Enteral route.

- Although the optimal dose of macronutrients is unclear, some amount of nutrient delivered as EN has been beneficial for gastrointestinal mucosal integrity and motility.
- Based on large cohort studies, early initiation of EN (within 24–48 h of PICU admission) and achievement of up to two-thirds of the nutrient goal in the first week of critical illness have been associated with improved clinical outcomes.

Advancing EN in the PICU Population

- On the basis of observational studies, the use of a stepwise algorithmic approach to advance EN in children admitted to the PICU is recommended.
- The stepwise algorithm must include bedside support to guide the detection and management of EN intolerance and the optimal rate of increase in EN delivery.

On the basis of observational studies, a nutrition support team, including a dedicated dietitian should be available on the PICU team, to facilitate timely nutrition assessment, and optimal nutrient delivery and adjustment to the patients.

Sites for and Initiation of EN

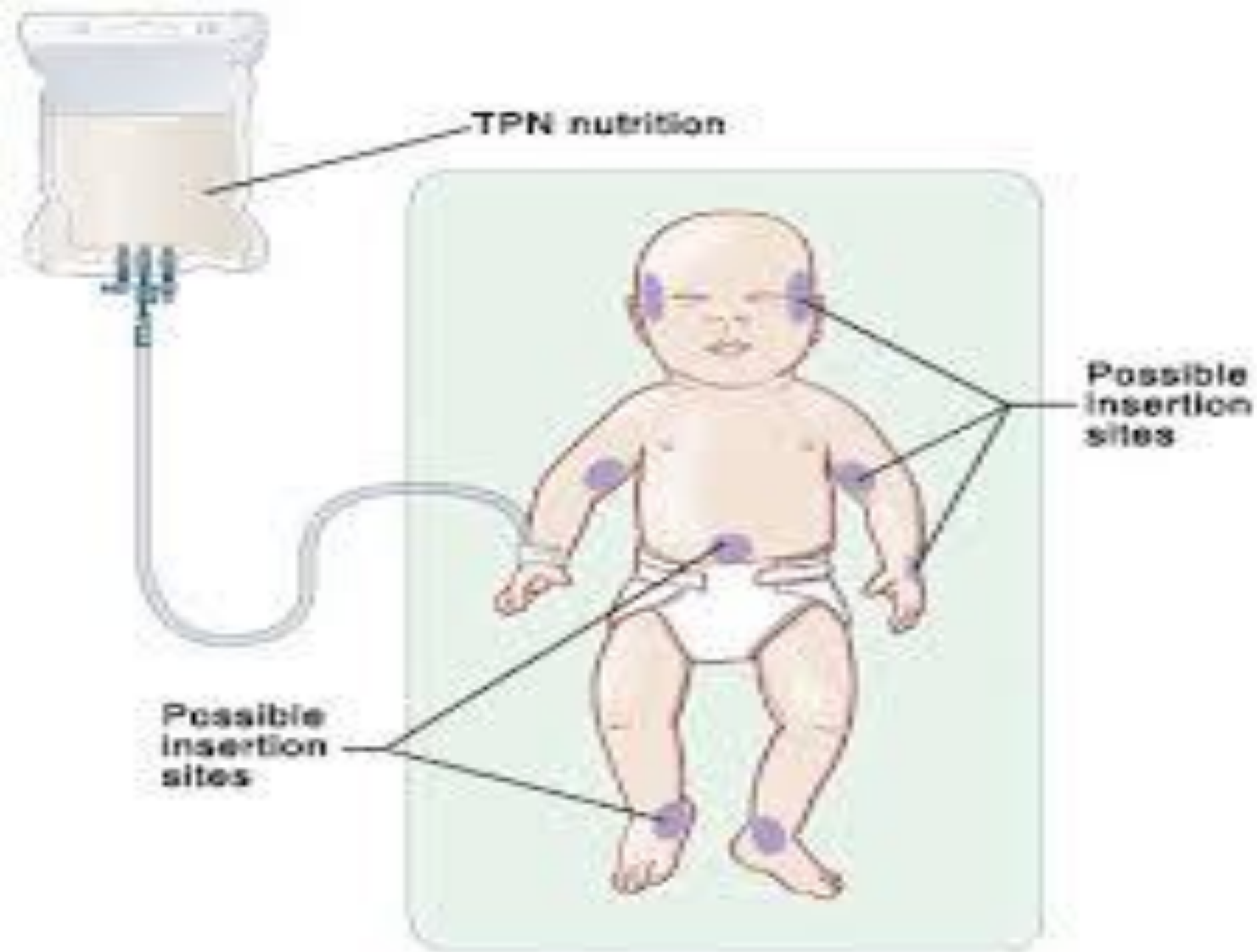
- Existing data are insufficient to make universal recommendations regarding the optimal site to deliver EN to critically ill children.
- On the basis of observational studies, the gastric route is suggested to be the preferred site for EN in patients in the PICU.

The postpyloric or small intestinal site for EN may be used in patients unable to tolerate gastric feeding or those at high risk for aspiration. Existing data are insufficient to make recommendations regarding the use of continuous vs intermittent gastric feeding.

- On the basis of expert opinion, it is suggested that EN should be initiated in all critically ill children, unless it is contraindicated.
- Given observational studies, early initiation of EN is suggested, within the first 24–48 h after admission to the PICU, in eligible patients.
- It is recommended to use the institutional EN guidelines and stepwise algorithms that include criteria for eligibility for EN, timing of initiation, and rate of increase, as well as a guide to detecting and managing EN intolerance.

Parenteral Nutrition & Critically ill Children

- On the basis of a single RCT, the initiation of PN within 24 h of PICU admission is not recommended.
- For children tolerating EN, stepwise advancement of nutrient delivery via the Enteral route and delaying commencement of PN is suggested.



- Based on current evidence, the role of supplemental PN to reach a specific goal for energy delivery is not known. The time when PN should be initiated to supplement insufficient EN is also unknown. The threshold for and timing of PN initiation should be individualized.
- Based on a single RCT, supplemental PN should be delayed until 1 wk after PICU admission for patients with normal baseline nutrition state and low risk of nutrition deterioration.

- On the basis of expert consensus, PN supplementation for children who are unable to receive any EN during the first week in the PICU is suggested.
- For patients who are severely malnourished or at risk of nutrition deterioration, PN may be supplemented in the first week if they are unable to advance past low volumes of EN.

Role of Immuno-nutrition in Critically ill Children

On the basis of available evidence, the use of immuno-nutrition in critically ill children is not recommended.

Summary

- Adequate intake of protein and energy maintains protein balance and prevents lean body mass depletion caused by metabolic stress
- Accurate assessment, and delivery of energy to match the patient's needs, are vital
- IC is the gold standard method of calculating energy needs; predictive equations can also be used

- Nutritional requirements that should be provided via EN are:
 - **Protein:** 1.5 g/kg (minimum recommended daily intake)
 - **Carbohydrate:** approximately 50–60% of total energy intake
 - **Fat:** 30–40% of total energy intake
- PN comprises a mixture of amino acids, carbohydrates, fat, electrolytes and micronutrients
 - As with EN, protein and energy delivery must be adjusted to the patient's requirements

- EN remains the preferred route for nutrient delivery and several strategies to optimize EN during critical illness have emerged.
- The role of supplemental PN has been highlighted, and a delayed approach appears to be beneficial.
- Immuno-nutrition cannot be currently recommended. Overall, the pediatric critical care population is heterogeneous, and a nuanced approach to individualize nutrition support with the aim of improving clinical outcomes is necessary.

References

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Quiz

1. During critical illness, the metabolic stress response initially causes resting metabolism (energy requirements) to:

A. Increase

B. Decrease

2. For estimating energy requirements in critically ill children, stress factors must always be included

A. Increase

B. Decrease

3. Which one of the statements listed below with regards to estimating energy and protein requirements is true?

a. In a patient admitted with severe burns, daily protein requirements can double

b. REE is independent of physical activity levels

c. In a neonate who has just had abdominal surgery, REE is elevated for 36 hours

d. REE is always increased in mechanically ventilated patients

4. Which predictive equation will usually yield the most accurate energy requirement estimation for PICU patients?

- a. White equation in infants aged <2 months
- b. Schofield equation with stress factors
- c. Schofield equation without stress factors
- d. Harris-Benedict equation

5. What are the estimated daily protein requirements for a 7-year-old PICU patient on EN according to ASPEN guidelines?

- a. 1.0 g/kg/day**
- b. 1.5–2 g/kg/day**
- c. 2–3 g/kg/day**
- d. 3–4 g/kg/day**

